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Volume Number Two

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Vacuum Cleaning

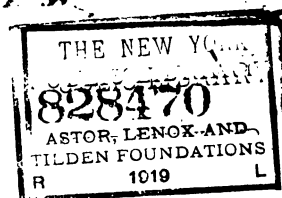


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PREFACE

The lack of a ready reference for use in calculation and specification of Vacuum Cleaning Systems has recently been felt by architects and engineers.

The rapid growth and development of the Vacuum Cleaning Industry in the past few years has led to many inquiries from architects and engineers from all parts of the country, for definite information on which to base calculations. It is the object of this hand-book to present to the engineer and architect logical and reliable information, compiled from long established data and formulae, together with such modifications as are found to apply to the transmission of air through pipes at a high velocity, under vacuum instead of direct pressure.

The tables on Velocity and Vacuum Loss in pipes are based on actual pipe sizes, such as are found in standard wrought iron or steel pipe.

Several other tables frequently used in connection with Vacuum Cleaning have been added, for which we are indebted to Kent's Hand Book for Mechanical Engineers and Foster's Hand Book for Electrical Engineers.

We hope this compilation of information and data will be given careful attention by all persons engaged in the architectural and engineering professions.

Engineering Department,
THE UNITED ELECTRIC COMPANY

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TUEC

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Runs Like a Watch

THE APPLICATION OF AIR TO VACUUM CLEANING.

AIR, the necessity for all vacuum cleaning, is a mechanical mixture of two gases, oxygen and nitrogen, in the ratio of 20.7 parts of the former to 79.3 parts of the latter by volume, and 23 of the former to 77 of the latter by weight.

The importance of air as the essential cleaning agent has not been properly recognized by the Vacuum Cleaning industry. The trade name, "Vacuum Cleaner," should more correctly have been Air Cleaner, for the very reason that a large volume of air, moving at a high velocity, is the only agent by means of which dirt or dust can be removed by a commercial vacuum cleaner.

It is impossible to use air as a cleaning agent unless some method is used to cause the air to move; i. e., a machine to produce pressure or partial vacuum; vacuum alone would be an empty space if air was not supplied.

A conductor is necessary to convey the air from the point being cleaned to the machine or vacuum-producer, and to convey the foul air from the machine or vacuum-producer to the place of disposal, such as a stack, chimney, etc. The conductor consists of a suitable tool, flexible vacuum hose, pipe of adequate size, separating tank and exhaust.

There are four essential parts necessary in a Stationary Air Cleaning System; namely, the machine, the conductor, the air or volume, and the vacuum. In taking up these parts it is necessary to treat each one separately.

THE MACHINE.

One who does not possess a working knowledge of the different types of machines now on





and should have a non-abrasive rubbing surface, such as felt, rubber, or some similar substance, to prevent scratching or marring of the floor. The general dimensions of these tools will depend on the volume of air displaced per tool by the machine or vacuum-producer.

There are two methods used in dealing with the separation of the dirt from the air; namely, wet and dry. In the wet system the dirt and dust-laden air is caused to come in contact with water in the form of spray or is forced to pass through a chamber partly filled with water. The water thus dissolves and holds in suspension part of the dirt, and then this solution is run into a sewer. A portion of the dust, however, is carried in the air passing through the water in the form of bubbles. This dust-laden air is then carried through the valves and pistons of the vacuum-producer used with this system of dust separation, causing great wear and abrasion of these accurately machined parts. The exhausting of this air under pressure into a sewer is also being condemned in many cities by the health authorities, owing to the fact that it produces back pressure in the sewer, causing sewer gas to be forced into the building, carrying with it the usual odor and unsanitary conditions. The dry separation of the dust and dirt from the air necessitates the removal of dirt from the separator in its dry state. It is then burned. The foul air passes through the exhaust pipe to the furnace or chimney, and thus escapes into the outside atmosphere. The small amount of dust carried out by the air in this manner is scarcely perceptible to the eye. If the tank is of sufficient capacity, the cleaning of it will be necessary only once or twice per month.

VOLUME AND VACUUM.

It is necessary to discuss Volume and Vacuum under the same head, owing to the close relation existing between them. As has been stated before, the volume of air is the one essential agent in vacuum cleaning. In order to cause the removal of dust and dirt, it is necessary to have a large volume of air in motion. Vacuum is only the difference of air pressure causing the flow of this volume. The proper relation between vacuum and volume in a Vacuum Cleaning system, together with the pipe system of adequate size to accommodate this volume without undue loss, determines the economy of the system in regard to power required to operate, as well as the ability of the system to do effective and thorough cleaning. Experiments made with high-vacuum low-volume machines, in comparison with low-vacuum high-volume machines, prove that there must be a proportionately larger power consumption to maintain the high-vacuum for the same effective cleaning. This is also shown by the commercial rating of the motors connected to these different type of machines.

It is then evident that the correct principle and design is that embodied in the large-volume low-vacuum machine. Architects and engineers have, at times, specified 40 cu. ft. of free air displacement per minute at the tool for the high-vacuum machines, and 60 to 80 cu. ft. of free air displacement per minute at the tool for the low-vacuum machines for the same effective cleaning. In order to have the same effective cleaning, each machine should displace from 60 to 80 cu. ft. of free air per minute, with .8 to 1 inch of mercury at the tool.

Therefore, by placing vacuum and volume in their proper relation to each other, the whole discussion is finally brought down to the point that vacuum is only the cause by which air is put in motion. An inch of mercury is very ample for effective cleaning.

with the displacement of 60 to 80 cu. ft. of air at the tool. When a machine can be designed to maintain these requirements without undue power consumption, a perfect Vacuum Cleaning System will be realized. The nearest approach to these conditions is found in the principle and design of the powerful high-speed centrifugal fan, which possesses the inherent capacity for large volume, constant vacuum and small power consumption.

Summarizing the comparative qualities of the high-vacuum low-volume machine, and the low-vacuum high-volume machine, the following differences are shown:

HIGH VACUUM.

First cost, large.
Large maintenance.
Large power consumption.
Small volume.
High vacuum at machine.
Variable vacuum at tool.
Small pipes.
Numerous sliding contacts.
One-inch vacuum at tool.

LOW VACUUM.

First cost, small.
Small maintenance.
Small power consumption.
Large volume.
Low vacuum at machine.
Constant vacuum at tool.
Medium pipes.
No sliding contacts.
One-inch vacuum at tool.

RELATION OF VOLUME AND VACUUM TO HORSE PÔWER.

In order to obtain a clear conception of the relation the above factors bear to each other, it is necessary to arrange the factors in the form of a curve, to which the following article pertains.

On the curve sheet following this article, vacuum has been used as ordinates on the left-hand side, and horse power, as ordinates on the right-hand side, volume being plotted as abscissae. To avoid confusion, the horse power has been plotted for only one specific case, that of a piston, centrifugal or positive exhauster, with a rated capacity of 80 cu. ft. of air displacement. This may be varied for any case by using the following formula, which has been developed from the steam engine formula for horse power of an engine:

$$H. P. = \frac{144 \times Q. P.}{33000}$$

H. P.=Horse Power.

Q.=Rated displacement of exhauster in cubic feet per min.

P.=Difference of air pressure of vacuum in pounds per sq. in.

From a well known law of Physics, the volume of a gas at constant temperature varies inversely as the pressure; i. e., if the pressure is doubled, the volume is reduced one-half; and again, if the pressure is reduced one-half, the volume is doubled. Thus, one can see if air at 14.7 lbs., or atmospheric pressure at sea level, is rarefied one-half, or a partial vacuum of practically 15 inches of mercury is attained, the volume of air is increased to twice the amount, by

the weight or density of the air is only one-half for the same volume as it was at atmospheric pressure.

A perfect vacuum is equal to practically 30 inches of mercury column. Thus, when an exhaustor or vacuum-producer maintains a vacuum of 10 inches of mercury, the air in the system is rarefied $33\frac{1}{3}$ per cent., as 10 inches of mercury is just one-third of a perfect vacuum. Therefore, the amount of free air displaced would not be equal to the rated capacity of the exhaustor, but only $66\frac{2}{3}$ per cent. of the rated capacity. (Friction in the machine is not taken into consideration here.)

When air becomes rarefied to any great extent, its density is so small that it loses its value as a cleaning agent. Air must have density and be associated with large volume in order to lift and carry with it the dirt and dust with which it comes in contact.

It is not essential to maintain a high vacuum, which necessitates the consumption of a large amount of energy. A high vacuum only causes a high velocity of rarefied or light-weight air, and does not produce the cleaning effect that a low vacuum does with a high volume of air near atmospheric density, or near full weight, with the proper velocity.

If it were possible to produce an absolutely perfect vacuum, the air would be so rarefied that it would have no density or weight whatever, and would, therefore, have no dust-carrying capacity, as air loses its carrying capacity correspondingly to the degree to which it is rarefied. As the vacuum *is gradually reduced*, the density of the air is *increased until a point is reached where a maximum amount of free air is displaced at a minimum amount of power consumed.*

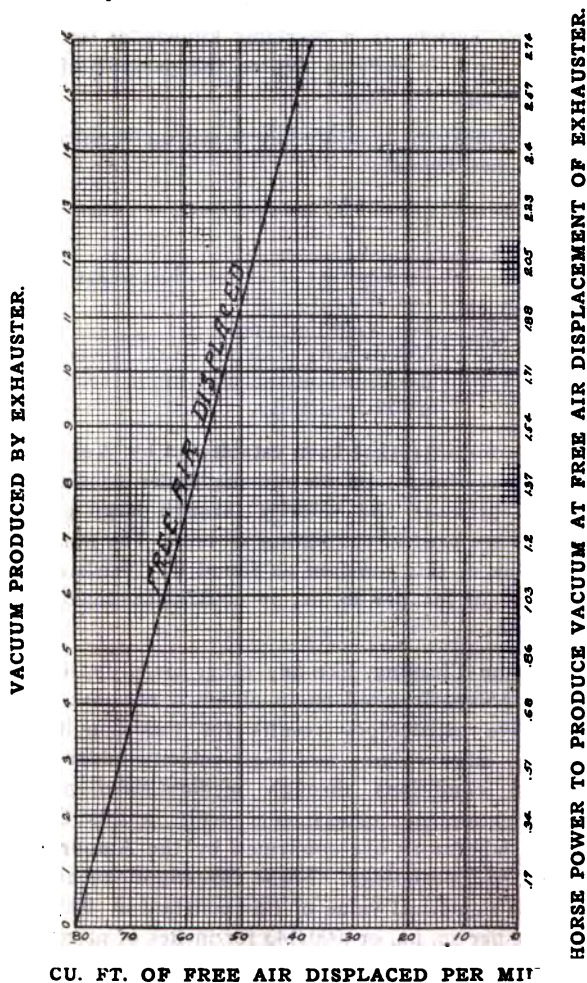
Experiments conducted by the Engineering Department of this Company have proven that a vacuum of one-half to one and one-half inches of mercury at the tool, according to the service requirements, is very satisfactory when associated with a large volume of air. The resistance of the air passing through the hose and pipe, from the point being cleaned to the vacuum-producer, causes a loss of vacuum in proportion to the size and length of the pipe. The passage of the volume of air, which is necessary to do effective cleaning, through the very small pipe that is used and recommended by the manufacturers of high-vacuum machines causes so great a loss that the vacuum at the tool will not exceed one-half to one and one-half inches of mercury, even though ten or fifteen inches are maintained at the vacuum-producer. Since the vacuum-producer is displacing rarefied air, the amount of free air entering the tool is reduced directly in proportion to the vacuum maintained, as explained in the foregoing paragraphs.

By referring to the free-air displacement curve on the following page, it will be noticed that a vacuum-producer having a rated displacement of 80 cu. ft. of air, maintaining ten inches of vacuum, consuming 1.71 H. P., will displace only about 53 cu. ft. of free air. When the same volume of free air is displaced at a vacuum of two inches, the power consumed is only 0.22 H. P. (This does not take into consideration the friction in the vacuum-producer.) Thus, it becomes apparent that the maintenance of a high vacuum is a fallacy; by using a *pipe of the proper size the air could be conveyed*

to the vacuum-producer, and the same vacuum maintained at the orifice of the tool as that shown by the high vacuum-producer. This would result in the same quality of cleaning.

The curve sheet shows that a vacuum-producer must have an inherent capacity for a large volume of air near atmospheric density, with only sufficient vacuum to overcome the vacuum loss due to the friction in the pipe (which should be of adequate size to convey the large volume of air) and produce a vacuum of $\frac{1}{2}$ inch in the smallest to $1\frac{1}{2}$ inch in the largest cleaning tool while in service.

Curve Sheet Showing Relation of Volume and Vacuum to Horse Power for Free Air Entering the Orifice of the Tool. Efficiency of the Machine is Not Taken in Consideration.



LOSS OF VACUUM IN PIPE AND HOSE.

The first essential in the specification of a Vacuum Cleaning system is a working knowledge of the loss or drop in vacuum due to the passage of air through pipe and hose.

The tables which follow are based on Weisbach's well known formula:

$$P=f\frac{LV^2}{d2g}$$

In which P =Pressure or Vacuum loss in lbs.
 f =Constant.
 L =Length or pipe in feet.
 V =Velocity of air in feet per second.
 d =Actual internal diameter in inches.
 g =32.2=Gravity.

The constant (f) has been established by Weisbach in his experiments on air moving under conditions of low pressure and velocity through large pipes, such as are used in ventilating systems. The numerical value of this constant as found by Weisbach is .0001608 for lbs. per sq. in., or .0003283 for inches of mercury.

Vacuum Cleaning, like any other air proposition, must be experimented on to obtain a constant that will give satisfactory results for this condition; namely, large volume and high velocity under low vacuum conditions through medium-sized pipes. Investigation and experiments made in this Company's laboratory are confirmed by the *Amour Institute of Technology*. These investigations establish the numerical value of this constant at .0001050 for lbs. per sq. in., or .0002143 for inches of mercury.

Including the value of 2g or 64.4, the constant is .000003329 for inches of mercury. The formula then becomes:

$$P = .000003329 \frac{LV^2}{d}$$

In which P=Vacuum loss in inches of mercury.
L=Length of pipe in feet.
V=Velocity of air in feet per second.
d=Actual internal diameter in inches.

The result of these calculations has been plotted with vacuum loss as ordinates and volume as abscissae, so that a physical conception may be had of the losses in the different sizes of pipe, as well as a ready reference for those who prefer the curve sheet to the tabulated form.

Vacuum Loss in Inches of Mercury for 100 Ft. of Standard Wrought Iron Pipe

Dia. in In.	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6
40	3.921	.991	.462	.132	.054	.018	.009	.0047	.0027	.0015	.0006
60	8.822	2.230	1.040	.296	.122	.041	.020	.0106	.0061	.0034	.0014
80	15.683	3.965	1.849	.527	.217	.073	.035	.0188	.0107	.0061	.0024
100	24.505	6.195	2.889	.823	.340	.114	.055	.0294	.0167	.0095	.0038
120	*35.286	8.920	4.160	1.186	.489	.165	.079	.0423	.0240	.0137	.0054
160	---	15.858	7.395	2.108	.870	.293	.141	.0752	.0428	.0243	.0095
180	---	20.071	9.360	2.668	1.101	.371	.179	.0952	.0549	.0308	.0124
200	---	24.779	11.555	3.293	1.360	.458	.221	.1175	.0668	.0380	.0151
240	---	*35.681	16.639	4.742	1.958	.659	.318	.1692	.0977	.0548	.0218
300	---	---	25.999	7.410	3.059	1.031	.497	.2644	.1503	.0856	.0341
320	---	---	29.581	8.431	3.481	1.172	.565	.3008	.1711	.0974	.0388
360	---	---	---	10.671	4.405	1.484	.715	.3808	.2197	.1232	.0491
400	---	---	---	13.174	5.439	1.832	.883	.4700	.2673	.1522	.0606
420	---	---	---	14.524	5.996	2.020	.974	.5183	.2991	.1677	.0668
480	---	---	---	18.950	7.832	2.638	1.272	.6769	.3906	.2191	.0872
500	---	---	---	28.584	8.498	2.863	1.371	.7345	.4176	.2377	.0872
600	---	---	---	29.640	12.237	4.122	1.987	1.0577	.6013	.3423	.1363
700	---	---	---	---	16.656	5.611	2.705	1.4396	.8185	.4660	.1855
800	---	---	---	---	21.755	7.328	3.533	1.8803	1.0691	.6086	.2423
900	---	---	---	---	27.534	9.273	4.471	2.3798	1.3530	.7703	.3066
1000	---	---	---	---	*33.992	11.450	5.520	2.9380	1.6704	.9510	.3786
1100	---	---	---	---	---	13.855	6.679	3.5550	2.0212	1.1507	.4581
1200	---	---	---	---	---	16.488	7.949	4.3207	2.4054	1.3694	.5452
1300	---	---	---	---	---	19.351	9.329	4.9652	2.8230	1.6072	.6398
1400	---	---	---	---	---	22.442	10.819	5.7585	3.2740	1.8639	.7420
1500	---	---	---	---	---	25.763	12.421	6.6105	3.7584	2.1397	.8518

Cubic Ft. of Air per Minute

NOTE: *Denotes Impossible loss—29.922 Hg. Inches Equals Perfect Vacuum

Vacuum Loss in Inches of Mercury for 100 Ft. of Standard Vacuum Hose

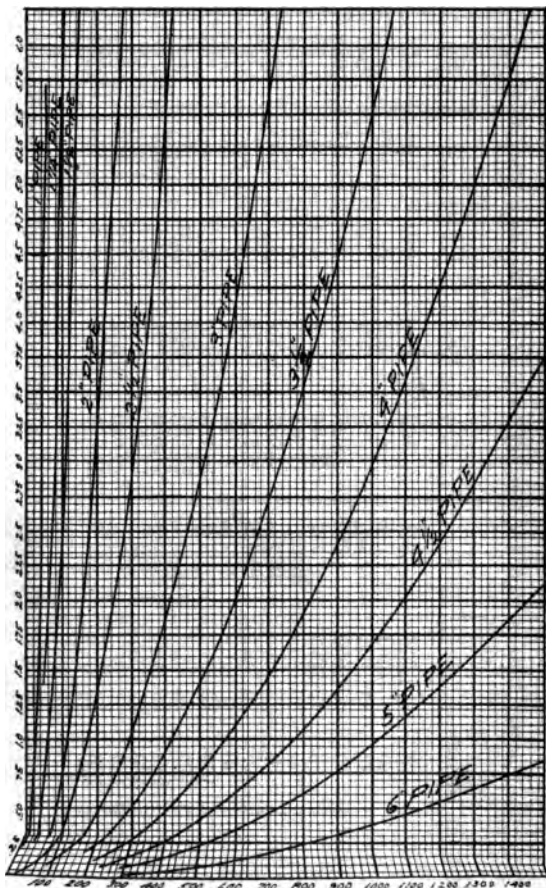
Dia. in Inches	¾	1	1¼	1½	1¾	2	2¼	2½
10	1.316	.311	.102	.041	.019	.010	.005	.003
20	5.262	1.245	.407	.163	.077	.039	.022	.013
30	11.840	2.802	.916	.369	.173	.087	.049	.029
40	21.050	4.981	1.628	.656	.307	.155	.086	.051
50	*32.890	7.783	2.544	1.024	.479	.242	.135	.080
60	-----	11.207	3.664	1.475	.690	.349	.194	.115
70	-----	15.254	4.987	2.008	.940	.475	.264	.157
80	-----	19.924	6.514	2.623	1.227	.620	.345	.205
90	-----	25.216	8.244	3.319	1.553	.785	.437	.259
100	-----	*31.131	10.178	4.098	1.917	.969	.540	.320
110	-----	-----	12.315	4.959	2.320	1.174	.653	.387
120	-----	-----	14.656	5.901	2.761	1.395	.777	.460
130	-----	-----	17.201	6.926	3.241	1.638	.912	.540
140	-----	-----	19.949	8.032	3.758	1.899	1.058	.627
150	-----	-----	22.900	9.220	4.314	2.180	1.214	.719

NOTE: *Denotes Impossible Loss—29.922 Hg. inches Equals Perfect Vacuum

Cubic Ft. of Air per Minute

Curve Sheet for Vacuum Loss in 100 Ft. of
Standard Wrought Iron Pipe.

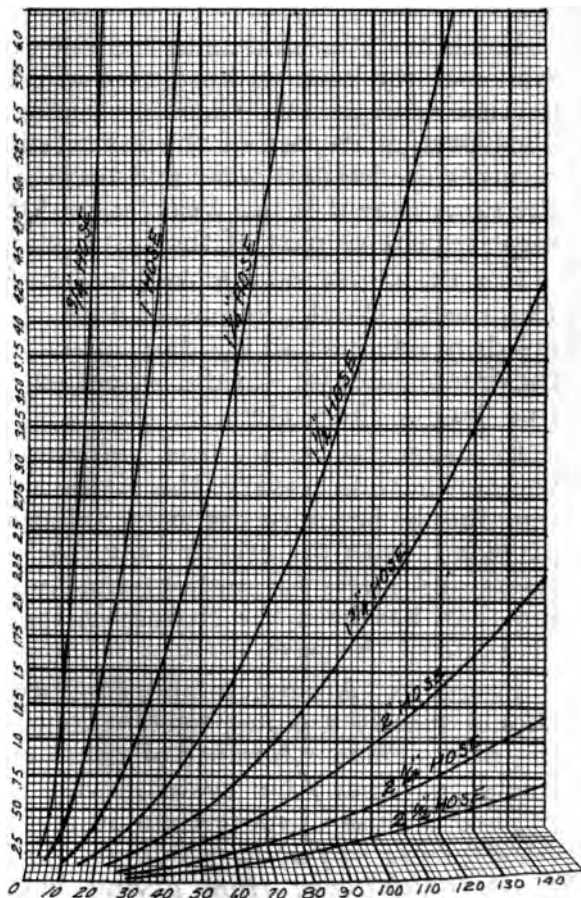
VACUUM LOSS PER 100 FT. OF STANDARD W. I. PIPE.



CU. FT. OF AIR PER MIN.

Curve Sheet for Vacuum Loss in 100 Ft. of
Standard Vacuum Hose.

VACUUM LOSS IN INCHES OF MERCURY.



CUBIC FEET OF AIR PER MINUTE.

THE USE AND ABUSE OF VACUUM HOSE.

Much has been said as to the Use and Abuse of the vacuum hose used in connection with an Air Cleaning System. This particular part of the installation receives the hardest wear and tear. At the same time it is the weakest, and the most expensive part of the installation.

For the above reason Architects and Engineers should impress upon the minds of owners and building managers the importance of careful attention to this part of the system.

In order to reduce the amount of vacuum hose necessary, the piping system should be more extensive; that is, provided with a greater number of risers and inlets throughout the building than has been the custom in specifications of the past.

Therefore, Architects and Engineers should specify a piping system consisting of a sufficient number of risers and inlets, so that the system will not require the use of more than 50 feet of *vacuum hose* in public buildings and 25 *feet in residences*; thus giving better *service at less cost of maintenance.*

VELOCITY TABLE.

The table of velocities shown on the following page is tabulated for a wide range of volume, in order to be of value for any size of machine, ranging from that used in the modern home to the machine designed for service in large buildings.

The actual internal cross-sectional area of wrought iron pipe is used in the calculation of the table, so as to conform exactly with conditions as found in practice. The values given in the table are used with Weisbach's common formula in the calculation of the table for loss in vacuum given on a preceding page. The velocities for air in standard vacuum hose have also been tabulated. Curves are plotted from these tabulations with velocity as ordinates and volume as abscissae for each size of pipe, thus giving a physical conception of the variation of velocity for the same volume through different sizes of pipe, as well as a ready reference for those who prefer the use of curve sheets rather than tabulated figures.

Velocity of Air in Ft. per Minute in Standard Wrought Iron Pipe

Dia. in In.	Velocity of Air in Ft. per Minute in Standard Wrought Iron Pipe										
	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6
40	6660	3850	2840	1720	1200	777	582	---	---	---	---
60	10000	5772	4255	2575	1807	1170	873	---	---	---	---
80	13330	7693	5674	3433	2409	1554	1164	---	---	---	---
100	16660	9615	7092	4291	3012	1949	1456	---	---	---	---
120	20000	11540	8512	5152	3614	2339	1747	1131	1083	---	---
160	---	15380	11350	6866	4820	3118	2329	1810	1444	1152	---
180	---	17320	12765	7725	5423	3509	2620	2036	1625	1296	---
200	---	19220	14185	8582	6025	3899	2911	2263	1805	1441	---
240	---	---	17020	10300	7232	4678	3495	2715	2166	1736	1196
300	---	---	21280	12870	9041	5847	4366	3393	2707	2160	1496
320	---	---	---	13730	9642	6236	4660	3621	2889	2306	1595
360	---	---	---	15450	10840	7019	5242	4072	3248	2594	1795
400	---	---	---	17160	12050	7796	5822	4525	3610	2881	1994
420	---	---	---	18030	12650	8188	6114	4752	3791	3025	2092
480	---	---	---	20590	14450	9357	6990	5429	4331	3472	2392
500	---	---	---	---	15060	9745	7277	5655	4512	3602	2493
600	---	---	---	---	18070	11690	8733	6786	5422	4323	2991
700	---	---	---	---	21080	13640	10180	7917	6315	5043	3489
800	---	---	---	---	---	15590	11640	9049	7220	5763	3988
900	---	---	---	---	---	17540	13080	10180	8122	6483	4485
1000	---	---	---	---	---	19490	14540	11310	9025	7204	4984
1100	---	---	---	---	---	---	16010	12440	9930	7920	5492
1200	---	---	---	---	---	---	17470	13570	10830	8640	5982
1300	---	---	---	---	---	---	18920	14700	11740	9360	6480
1400	---	---	---	---	---	---	20360	15840	12630	10090	6979
1500	---	---	---	---	---	---	21830	16970	13540	10810	7477

Cubic Ft. of Air per Minute

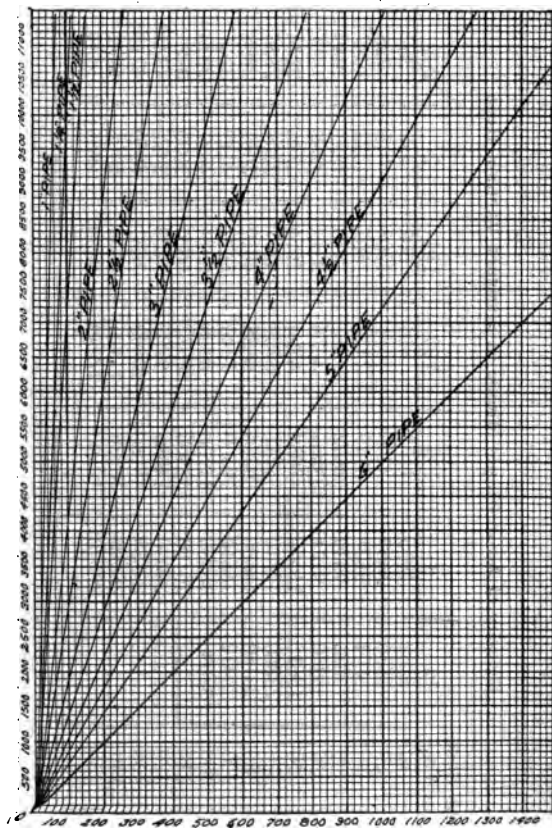
Velocity of Air in Ft. per Minute in Standard Vacuum Hoses

Dia. of hose in inches.	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$
10	3268	1835	1173	816	602	458	362	294
20	6536	3669	2346	1631	1205	915	725	588
30	9804	5504	3519	2447	1807	1373	1087	882
40	13070	7339	4692	3262	2410	1831	1449	1176
50	16340	9174	5865	4078	3012	2288	1811	1470
60	19610	11010	7038	4894	3614	2746	2174	1764
70	22880	12840	8211	5709	4217	3204	2536	2058
80	26140	14680	9384	6525	4819	3661	2898	2352
90	29412	16510	10560	7340	5422	4119	3261	2646
100	32680	18350	11730	8156	6024	4577	3623	2940
110	---	20180	12900	8972	6626	5035	3985	3234
120	---	22020	14080	9787	7229	5492	4348	3528
130	---	23850	15250	10600	7831	5950	4710	3822
140	---	25690	16420	11420	8434	6408	5072	4116
150	---	27520	17590	12230	9036	6865	5434	4410

Cubic Ft. of Air per Minute

Curve Sheet for Velocity of Air in Standard Wrought Iron Pipe.

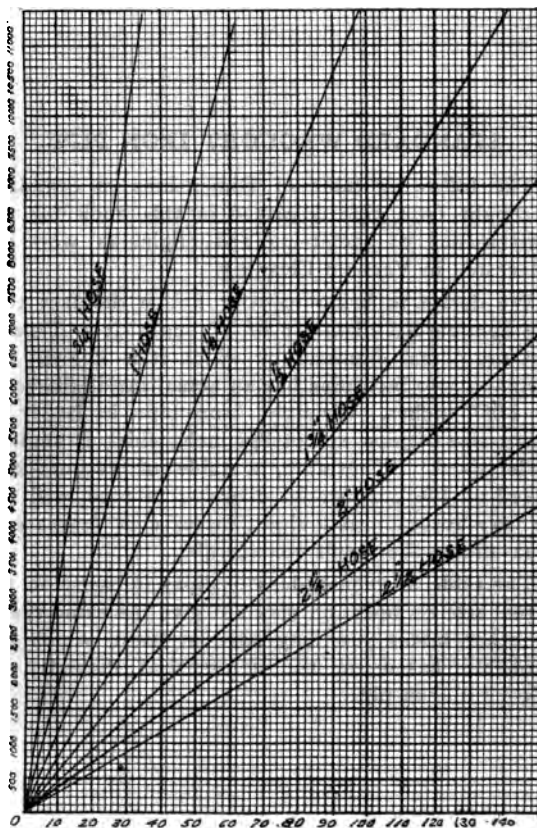
VELOCITY OF AIR IN FT. PER MIN.



CU. FT. OF AIR PER MIN.

Curve Sheet for Velocity of Air in Standard Vacuum Hose.

VELOCITY OF AIR IN FEET PER MIN.



CU. FT. OF AIR PER MIN.

STANDARD WROUGHT IRON PIPE.

The following table of Dimensions of Standard Wrought Iron pipe is placed in this book for the convenience of architects and engineers who are interested in Vacuum Cleaning.

We desire to bring to your notice the fact that the commercial diameter of Wrought Iron Pipe is not the actual diameter by which it is known; for instance, two inch pipe has an actual inside diameter of 2.067 inches. Wrought Iron pipe is larger in every size of pipe except 2½ inch, which is slightly under-sized. Therefore, a table of vacuum-loss, based on the commercial diameter of pipe, will not be very accurate, as a slight increase or decrease in area affects the result considerably.

The table of vacuum-loss in pipes is based on the actual size of pipe, and may not give the same result as other tables you may have at hand, which are probably based on the commercial diameter of Wrought Iron pipe.

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DIMENSIONS OF STANDARD BLACK OR GALVANIZED
WROUGHT IRON PIPE.

Inches	Inches	Inches	Inches	Inches	Inches	Inches	INTERNAL AREA		EXTERNAL AREA		Number	Inches	Inches	Inches
							Sq. Inches	Sq. Feet	Sq. Inches	Sq. Feet				
1/8	.405	.270	.068	.848	1.272	.057	.0004	.1288	.0009	.0027	27	.19	.334	.393
1/4	.540	.364	.088	1.144	1.696	.104	.0007	.2290	.0016	.0038	18	.29	.433	.522
3/8	.675	.493	.091	1.552	2.121	.191	.0013	.3578	.0025	.0058	18	.30	.568	.658
1/2	.840	.622	.109	1.957	2.639	.304	.0021	.554	.0038	.0091	14	.39	.701	.815
5/8	1.050	.824	.113	2.589	3.299	.533	.0037	.866	.0060	.0144	14	.40	.911	1.025
3/4	1.315	1.048	.134	3.292	4.131	.861	.0060	1.358	.0094	.0223	11 1/2	.51	1.144	1.283
1	1.660	1.380	.140	4.335	5.215	1.496	.0104	2.164	.0150	.0354	11 1/2	.54	1.488	1.627
1 1/4	1.900	1.610	.145	5.058	5.969	2.036	.0141	2.835	.0197	.0451	11 1/2	.55	1.727	1.866
1 1/2	2.375	2.067	.154	6.434	7.461	3.356	.0233	4.430	.0308	.0711	8	.58	2.223	2.339
2	2.875	2.468	.204	7.753	9.032	4.780	.0332	6.492	.0451	.1041	8	.89	2.620	2.820
2 1/2	3.500	3.067	.217	9.635	10.996	7.383	.0513	9.621	.0668	.1511	8	.95	3.241	3.441
3	4.000	3.548	.226	11.146	12.566	9.887	.0687	12.566	.0875	.1961	8	1.00	3.738	3.938
3 1/2	4.500	4.026	.237	12.648	14.137	12.730	.0884	15.904	.1104	.2431	8	1.05	4.234	4.434
4	5.000	4.508	.246	14.162	15.708	15.961	.1108	19.635	.1364	.3011	8	1.10	4.731	4.931
4 1/2	5.563	5.045	.259	15.849	17.475	19.986	.1388	24.301	.1688	.3741	8	1.16	5.290	5.490
5	6.625	6.065	.280	19.054	20.813	28.890	.2006	34.472	.2394	.5464	8	1.26	6.346	6.546
6	7.625	7.023	.301	22.063	23.955	38.738	.2690	45.664	.3171	.7140	8	1.36	7.340	7.540
7	8.625	7.981	.322	25.076	27.096	50.027	.3474	58.426	.4057	.9034	8	1.46	8.334	8.534
8	9.625	8.937	.344	28.076	30.238	62.730	.4356	72.760	.5053	.1145	8	1.57	9.327	9.527
10	10.75	10.018	.366	31.476	33.772	78.823	.5474	90.763	.6303	.1445	8	1.68	10.445	10.645

EQUATION OF PIPES.

It is frequently desirable to know what number of pipes of a given size are equal, in capacity, to one pipe of a larger size. At the same velocity of flow, the volume delivered by two pipes of different sizes is proportional to the squares of their internal diameters, but the same vacuum will not produce the same velocity in pipes of different sizes or lengths, the difference usually being stated to vary as the square root of fifth power of the diameter. The friction of the air within itself is very slight; therefore, the main resistance to flow is the friction upon the sides of the pipe. This extends to a limited distance, and is, of course, greater in proportion to the contents of a small pipe than of a large. It may be approximated in a given pipe by a constant multiplied by the diameter, or the ratio of flow found by dividing some power of the diameter by the diameter increased by a constant.

Careful comparison of a large number of experiments, by different investigators, has developed the following as a close approximation to relative flow in pipes of different sizes under similar conditions:

$$R \left(\frac{d^5}{d \times 3.6} \right) = \frac{d_1^5}{d_1 \times 3.6}$$

R=Ratio of small pipe.

d=Internal Diameter of small pipe.

d₁=Internal Diameter of large pipe.

The table on the following page gives the number of pipes of one size required to equal in volume larger pipes of the same length and under the same

conditions. The upper portion above the diagonal line of blanks pertains to "standard" Wrought Iron pipes, while the lower portion is for pipe of the actual internal diameters given. The figures given in the table opposite the intersection of any two sizes is the number of smaller sized pipes required to equal one larger. Thus, one $2\frac{1}{2}$ inch Wrought Iron pipe is equal to 3.34 $1\frac{1}{2}$ inch pipes.

TABLE OF EQUATION OF PIPES
Standard Wrought Iron Pipe

TABLE OF EQUATION OF PIPES														
Standard Wrought Iron Pipe														
Dia.	1/2	3/4	1	1 1/2	2	2 1/2	3	4	5	6	7	8	9	Dia.
1/2	2.60	2.27	4.88	15.8	31.7	52.9	96.9	205	377	620	918	1292	1767	1/2
3/4	7.55	2.90	2.05	6.97	14.0	23.3	42.5	90.4	166	273	405	569	779	3/4
1	24.2	9.30	3.20	3.45	6.82	11.4	20.9	44.1	81.1	133	198	278	380	1
1 1/2	54.8	21.0	7.25	2.26	1.26	3.34	6.13	13.0	23.8	39.2	58.1	81.7	112	1 1/2
2	102	39.4	13.6	4.23	---	1.67	3.06	6.47	11.9	19.6	29.0	40.8	55.8	2
2 1/2	170	65.4	22.6	7.03	1.87	1.66	2.21	2.12	3.89	6.39	9.48	13.3	20.9	2 1/2
3	376	144	49.8	15.5	6.87	3.67	4.03	---	1.84	3.02	4.48	6.30	8.61	3
4	686	263	90.9	28.3	12.5	6.70	6.56	1.83	---	1.65	2.44	3.43	4.69	4
5	1116	429	148	46.0	20.4	10.9	10.0	2.97	---	---	1.48	2.09	2.85	5
6	1707	656	226	70.5	31.2	16.6	14.3	4.54	2.49	1.51	---	1.41	1.93	6
7	2435	936	322	101	44.5	23.8	19.5	6.48	3.54	2.18	1.43	---	1.35	7
8	3335	1281	440	137	60.8	32.5	25.8	8.85	4.85	2.98	1.95	1.37	---	8
9	4393	1688	582	181	80.4	42.9	33.1	11.7	6.40	3.93	2.57	1.80	1.32	9
10	5642	2168	747	233	103	55.1	41.6	15.0	8.22	5.05	3.31	2.32	1.70	10
11	7087	2723	938	293	129	69.2	18.8	10.3	6.34	4.15	2.91	2.13	1.32	11
12														12
Dia.	1/2	3/4	1	1 1/2	2	2 1/2	3	4	5	6	7	8	9	Dia.
1/2	---	---	---	---	---	---	---	---	---	---	---	---	---	1/2
3/4	---	---	---	---	---	---	---	---	---	---	---	---	---	3/4
1	---	---	---	---	---	---	---	---	---	---	---	---	---	1
1 1/2	---	---	---	---	---	---	---	---	---	---	---	---	---	1 1/2
2	---	---	---	---	---	---	---	---	---	---	---	---	---	2
2 1/2	---	---	---	---	---	---	---	---	---	---	---	---	---	2 1/2
3	---	---	---	---	---	---	---	---	---	---	---	---	---	3
4	---	---	---	---	---	---	---	---	---	---	---	---	---	4
5	---	---	---	---	---	---	---	---	---	---	---	---	---	5
6	---	---	---	---	---	---	---	---	---	---	---	---	---	6
7	---	---	---	---	---	---	---	---	---	---	---	---	---	7
8	---	---	---	---	---	---	---	---	---	---	---	---	---	8
9	---	---	---	---	---	---	---	---	---	---	---	---	---	9
10	---	---	---	---	---	---	---	---	---	---	---	---	---	10
11	---	---	---	---	---	---	---	---	---	---	---	---	---	11
12	---	---	---	---	---	---	---	---	---	---	---	---	---	12
Actual Diameter of Pipe														

Actual Diameter of Pipe

MEASUREMENT OF VACUUM.

The common method of measuring the difference of pressure produced by a Vacuum Cleaner is by means of the mercury column; that is, by use of the manometer tube filled with mercury, and graduated in decimal or fractional parts of the inch.

Many Engineers and Architects, however, are more familiar with vacuum or difference of pressure measured in inches of water or in ounces per square inch. The table following has been compiled with inches of mercury as a basis, showing the equivalent values in inches of water and ounces per square inch. The following values were used in the calculation of the table:

1 in. of Mercury at 62° F.=	{ 7.86 oz. per sq. in. 13.58 in. of water at 62° F.
1 in. of Water at 62° F.=	{ 0.5774 oz. per sq. in. 0.0736 in. of mercury at 62° F.
1 ounce per square inch=	{ 0.1276 in. of mercury at 62° F. 1.732 in. of water at 62° F.

It should be borne in mind that the term "Vacuum", as used in the commercial sense, simply expresses a difference of atmospheric pressure.

Values of Mercury Column in Equivalent Inches of
Water and Ounces Per Square Inch.

Note: Temperature 62 Degrees F.

HG.	Water	Ounces	HG.	Water	Ounces	HG.	Water	Ounces
0.1	1.36	0.79	4.1	55.68	32.23	8.1	110.00	63.67
0.2	2.72	1.57	4.2	57.04	33.01	8.2	111.36	64.45
0.3	4.07	2.36	4.3	58.39	33.80	8.3	112.71	65.24
0.4	5.43	3.14	4.4	59.75	34.58	8.4	114.07	66.02
0.5	6.79	3.93	4.5	61.11	35.37	8.5	115.43	66.81
0.6	8.15	4.72	4.6	62.47	36.16	8.6	116.79	67.50
0.7	9.51	5.50	4.7	63.83	36.94	8.7	118.15	68.38
0.8	10.86	6.29	4.8	65.18	37.73	8.8	119.50	69.17
0.9	12.22	7.07	4.9	66.54	38.51	8.9	120.86	69.95
1.0	13.58	7.86	5.0	67.90	39.30	9.0	122.22	70.74
1.1	14.94	8.65	5.1	69.26	40.09	9.1	123.58	71.53
1.2	16.30	9.43	5.2	70.62	40.87	9.2	124.94	72.31
1.3	17.65	10.22	5.3	71.97	41.66	9.3	126.29	73.10
1.4	19.01	11.00	5.4	73.33	42.44	9.4	127.65	73.88
1.5	20.37	11.79	5.5	74.69	43.23	9.5	129.01	74.67
1.6	21.73	12.58	5.6	76.05	44.02	9.6	130.37	75.46
1.7	23.09	13.36	5.7	77.41	44.80	9.7	131.73	76.24
1.8	24.44	14.15	5.8	78.76	45.59	9.8	133.08	77.03
1.9	25.80	14.93	5.9	80.12	46.37	9.9	134.44	77.81
2.0	27.16	15.72	6.0	81.48	47.16	10.0	135.80	78.60
2.1	28.52	16.51	6.1	82.84	47.95	10.1	137.16	79.39
2.2	29.88	17.29	6.2	84.20	48.73	10.2	138.52	80.17
2.3	31.23	18.08	6.3	85.55	49.52	10.3	139.87	80.96
2.4	32.59	18.86	6.4	86.91	50.30	10.4	141.23	81.74
2.5	33.95	19.65	6.5	88.27	51.09	10.5	142.59	82.53
2.6	35.31	20.44	6.6	89.63	51.88	10.6	143.94	83.32
2.7	36.67	21.22	6.7	90.99	52.66	10.7	145.31	84.10
2.8	38.02	22.01	6.8	92.34	53.45	10.8	146.66	84.89
2.9	39.38	22.79	6.9	93.70	54.23	10.9	148.02	85.67
3.0	40.74	23.58	7.0	95.06	55.02	11.0	149.38	86.46
3.1	42.10	24.37	7.1	96.42	55.81	11.1	150.74	87.25
3.2	43.46	25.15	7.2	97.78	56.59	11.2	152.10	88.03
3.3	44.82	25.94	7.3	99.13	57.38	11.3	153.45	88.82
3.4	46.17	26.72	7.4	100.49	58.16	11.4	154.81	89.60
3.5	47.53	27.51	7.5	101.85	58.95	11.5	156.17	90.39
3.6	48.89	28.30	7.6	103.21	59.74	11.6	157.53	91.18
3.7	50.25	29.08	7.7	104.57	60.52	11.7	158.89	91.96
3.8	51.61	29.87	7.8	105.92	61.31	11.8	160.24	92.75
3.9	52.96	30.65	7.9	107.28	62.09	11.9	161.60	93.53
4.0	54.32	31.44	8.0	108.64	62.88	12.0	162.96	94.3

ALLOWABLE CARRYING CAPACITIES OF COPPER WIRES.

This table is taken from the Rules and Requirements of the National Board of Fire Underwriters, as given in Section 18 of the National Electric Code for the year 1911, which section reads as follows:

"The allowable carrying capacity of copper wires and cables of ninety-eight per cent. conductivity, according to the standard adopted by the American Institute of Electrical Engineers, must be followed in placing interior conductors.

"For insulated aluminum wire the safe carrying capacity is eighty-four per cent. of that given in the following tables for copper wire with the same kind of insulation.

"The lower limit is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires, but not from fear of igniting the insulation. The question of drop is not taken into consideration in the tables given below."

TABLE A		TABLE B	
Rubber Insulation		Other Insulations	
B. & S. G.	Amperes.	Amperes.	Circular Mils.
18.....	3.....	5.....	1,624
16.....	6.....	8.....	2,583
14.....	12.....	16.....	4,107
12.....	17.....	23.....	6,530
10.....	24.....	32.....	10,380
8.....	33.....	46.....	16,510
6.....	46.....	65.....	26,250
5.....	54.....	77.....	33,100
4.....	65.....	92.....	41,740
3.....	76.....	110.....	52,630
2.....	90.....	131.....	66,370
1.....	107.....	156.....	83,690
0.....	127.....	185.....	105,500
00.....	150.....	220.....	133,100
000.....	177.....	262.....	167,800
0000.....	210.....	312.....	211,600

COPPER WIRE TABLES.

On the following pages are given the Copper Wire Tables of the American Institute of Electrical Engineers. The table for the Brown and Sharpe gauge is derived from the following formula:

$$d = \frac{0.3249}{(1.123)^n}$$

$$\text{C.M.} = \frac{105,500}{(1.261)^n}$$

$$r = 0.09811 \times (1.261)^n$$

$$w = \frac{319.5}{(1.261)^n}$$

In which n = wire gauge number.

d = diameter of wire in inches.

C.M. = area in circular mils.

r = resistance in ohms per 1000 ft. at 20° C

w = weight in pounds per 1000 ft.

A useful approximate formula for resistance per 1000 feet at about 20° C is:

$$r = 0.1 \times (2)^{\frac{n}{3}} \quad (2^{\frac{1}{3}} = 1.26; \quad 2^{\frac{2}{3}} = 1.59)$$

From this table, it is seen that an increase of 3 in the wire number corresponds to doubling the resistance and halving the cross section and weight, and that an increase of 10 in the wire number increases the resistance 10 times and diminishes the cross section and weight to 1-10 their original value.

COPPER WIRE TABLE OF AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
 Giving Weights and Resistances of Cool and Hot Wires of Mathieson's Standard
 of Conductivity—Brown & Sharpe Gauge.

B.S. Gauge	Diam. Inches	Area		Weights		Resistance in International Ohms			
		Circular Mils	Square Mils	Pounds per Ohm	Lbs. per 1000 ft.	At 68° F. 20° C.	At 170° F. 80° C.	At 180° F. 80° C.	Ohms per 1000 ft.
0000	0.460	211600	166190	13090	640.5	0.00007639	0.00009459	0.04893	0.06058
000	0.4096	167800	131790	8232	508.0	0.0001215	0.0001504	0.06170	0.07640
00	0.3648	133100	104518	5177	402.8	0.0001931	0.0002391	0.07780	0.09633
0	0.3249	105500	82887	3256	319.5	0.0003071	0.0003803	0.09811	0.1215
1	0.2893	83690	65732	2048	253.3	0.0004883	0.0006046	0.1237	0.1532
2	0.2576	66370	52128	1288	200.9	0.0007765	0.0009614	0.1560	0.1932
3	0.2294	52630	41339	810.0	159.3	0.001235	0.001529	0.1967	0.2435
4	0.2043	41740	32784	509.4	126.4	0.001963	0.002431	0.2480	0.3071
5	0.1819	33100	25999	320.4	100.2	0.003122	0.003865	0.3128	0.3873
6	0.1620	26250	20618	201.5	79.46	0.004963	0.006145	0.3944	0.4883
7	0.1443	20820	16315	126.7	63.02	0.007892	0.009772	0.4973	0.6158
8	0.1285	16510	12967	79.69	49.98	0.01255	0.01554	0.6271	0.7765
9	0.1144	13090	10283	50.12	39.63	0.01995	0.02471	0.7908	0.9791
10	0.1019	10380	8155	31.52	31.43	0.03173	0.03928	0.9972	1.235
11	0.09074	8234	6467	19.82	24.93	0.05045	0.06246	1.297	1.557
12	0.08081	6530	5129	12.47	19.77	0.08022	0.09932	1.586	1.963
13	0.07196	5178	4067	7.840	15.68	0.1276	0.1579	1.999	2.476
14	0.06408	4107	3225	4.931	12.43	0.2028	0.2511	2.521	3.122
15	0.05707	3257	2558	3.101	9.858	0.3225	0.3993	3.179	3.936
16	0.05082	2583	2029	1.950	7.818	0.5128	0.6349	4.009	4.964

B&S Gauge	Diam. Inches	Area		Weights		Resistance in International Ohms			
		Circular Mils.	Square Mils.	Pounds per Ohm	Lbs. per 1000 ft.	Ohms per Pound		Ohms per 1000 ft.	
						At 68° F. 30° C.	At 118° F. 50° C.	At 68° F. 30° C.	At 118° F. 50° C.
17	0.04526	2048.0	1609	1.226	6.200	0.8153	1.010	5.055	6.259
18	0.04030	1624.0	1276	0.7713	4.917	1.296	1.605	6.374	7.892
19	0.03589	1288.0	1012	0.4851	3.899	2.061	2.552	8.038	9.952
20	0.03196	1022.0	802	0.3051	3.092	3.278	4.058	10.14	12.55
21	0.02846	810.1	636.3	0.1919	2.452	5.212	6.453	12.78	15.83
22	0.02535	642.4	504.6	0.1207	1.945	8.287	10.26	16.12	19.96
23	0.02257	509.5	400.2	0.07509	1.542	13.18	16.32	20.32	25.16
24	0.02010	404.0	317.3	0.04773	1.223	20.95	25.94	25.63	31.73
25	0.01790	320.4	251.7	0.03002	0.9699	33.32	41.25	32.31	40.01
26	0.01594	254.1	199.6	0.01888	0.7692	52.97	65.59	40.75	50.45
27	0.01420	201.5	158.3	0.01187	0.6100	84.23	104.3	51.38	63.62
28	0.01264	159.8	125.5	0.007466	0.4837	133.9	165.8	64.79	80.22
29	0.01126	126.7	99.53	0.004696	0.3836	213.0	263.7	81.70	101.2
30	0.01003	100.5	78.94	0.002953	0.3042	338.6	419.3	103.0	127.6
31	0.008928	79.70	62.60	0.001857	0.2413	538.4	666.7	129.9	160.8
32	0.007950	63.21	49.64	0.001168	0.1913	856.2	1060.0	163.8	202.8
33	0.007080	50.13	39.37	0.0007346	0.1517	1361.0	1685.0	206.6	255.8
34	0.006305	39.75	31.22	0.0004620	0.1203	2165.0	2680.0	260.5	322.5
35	0.005615	31.52	24.76	0.0002905	0.09543	3441.0	4262.0	328.4	406.7
36	0.005000	25.00	19.64	0.0001827	0.07568	5473.0	6776.0	414.2	512.9
37	0.004453	19.83	15.57	0.0001149	0.06001	8702.0	10770.0	522.2	646.6
38	0.003965	15.72	12.35	0.0000721	0.04759	13870.0	17170.0	658.5	815.4
39	0.003531	12.47	9.79	0.00004545	0.03744	22000.0	27240.0	830.4	1028.0
40	0.003145	9.888	7.77	0.00002858	0.02993	34980.0	43320.0	1047.0	1296.0

**DECIMALS OF AN INCH AND FOOT
FOR EACH $\frac{1}{4}$**

Fraction	$\frac{1}{8}$	$\frac{1}{4}$	Decimals of an Inch	Decimals of a Foot	Fraction	$\frac{1}{8}$	$\frac{1}{4}$	Decimals of an Inch	Decimals of a Foot
--	--	1	.015625	.0013	--	--	33	.515625	.0430
--	1	--	.031250	.0026	--	17	--	.531250	.0443
--	--	3	.046875	.0039	--	--	35	.546875	.0456
$\frac{1}{8}$	--	--	.062500	.0052	$\frac{1}{8}$	--	--	.562500	.0469
--	--	5	.078125	.0065	--	--	37	.578125	.0472
--	3	--	.093750	.0078	--	19	--	.593750	.0495
--	--	7	.109375	.0091	--	--	39	.609375	.0508
$\frac{1}{8}$	--	--	.125000	.0104	$\frac{1}{8}$	--	--	.625000	.0521
--	--	9	.140625	.0117	--	--	41	.640625	.0534
--	5	--	.156250	.0130	--	21	--	.656250	.0547
--	--	11	.171875	.0143	--	--	43	.671875	.0560
$\frac{1}{8}$	--	--	.187500	.0156	$\frac{1}{8}$	--	--	.687500	.0573
--	--	13	.203125	.0169	--	--	45	.703125	.0586
--	7	--	.218750	.0182	--	23	--	.718750	.0599
--	--	15	.234375	.0195	--	--	47	.734375	.0612
$\frac{1}{4}$	--	--	.250000	.0208	$\frac{1}{4}$	--	--	.750000	.0625
--	--	17	.265625	.0221	--	--	49	.765625	.0638
--	9	--	.281250	.0234	--	25	--	.781250	.0651
--	--	19	.296875	.0247	--	--	51	.796875	.0664
$\frac{1}{8}$	--	--	.312500	.0260	$\frac{1}{8}$	--	--	.812500	.0677
--	--	21	.328125	.0273	--	--	53	.828125	.0690
--	11	--	.343750	.0286	--	27	--	.843750	.0703
--	--	23	.359375	.0299	--	--	55	.859375	.0716
$\frac{3}{8}$	--	--	.375000	.0313	$\frac{3}{8}$	--	--	.875000	.0729
--	--	25	.390625	.0326	--	--	57	.890625	.0742
--	13	--	.406250	.0339	--	29	--	.906250	.0755
--	--	27	.421875	.0352	--	--	59	.921875	.0768
$\frac{1}{8}$	--	--	.437500	.0365	$\frac{1}{8}$	--	--	.937500	.0781
--	--	29	.453125	.0378	--	--	61	.953125	.0794
--	15	--	.468750	.0391	--	31	--	.968750	.0807
--	--	31	.484375	.0404	--	--	63	.984375	.0820
$\frac{3}{4}$	--	--	.500000	.0417	1	--	--	1.000000	.0833

EXEMPLARY FORM OF SPECIFICATIONS FOR LARGE BUILDINGS.

NOTICE TO BIDDERS.

Bids will be received this _____ day
of _____, 19____, for the installa-
tion of a Vacuum Cleaning System in the _____

located at _____

Bids must cover the System complete, subject to
the following Specifications and Drawings of the
Architect.

The _____ will
reserve the right to reject any or all bids or any part
thereof.

SPECIFICATIONS.

These Specifications shall cover all labor and
material to install completely, ready for operation,
the Cleaning System in _____,
located at _____

as per specifications, for the purpose of removing
and thoroughly cleaning dust and dirt from carpets,
rugs, walls, floors, upholstery, furniture, etc.

VACUUM PRODUCER.

The Vacuum Producer shall have a capacity of
_____sweepers operating simultaneously.
The system shall be capable of producing the same
effective cleaning with one or any number of
sweepers equal to the capacity of the system in
operation. It shall also be capable of displacing a
minimum volume of 60 cu. ft. of air per minute per
sweeper with all sweepers in operation, and with
*this displacement there shall be maintained a mini-
mum vacuum of 0.8 inch of mercury at the tool.*

MOTIVE POWER.

The power consumption shall not exceed an average of $2\frac{1}{2}$ H. P. per sweeper.

Electrical motive power is required.

D. C. current at-----volts.

A. C. current at-----volts,-----
phase,-----cycles.

The temperature rise of the motor shall conform to the rules of the A. I. E. E.

The wiring is provided for in the electrical contractor's work, the supply lines terminating in the space or room in which the motor is to be installed, as shown in blue-prints.

The Vacuum Cleaner contractor shall furnish cut-outs, fuses, and starting box required at the machine.

All wiring shall conform to the National Underwriters' rules and pass the city inspection.

DIRT SEPARATOR.

The dirt separator, if required by the system, shall be built of steel and installed on a foundation furnished by the contractor, and shall be of adequate size to accommodate the system when all sweepers are in operation. The tank shall be provided with all appliances necessary for the cleaning of same, and shall be substantially constructed.

PIPE INSTALLATION.

The architect shall indicate the location of each intake on the drawing. The contractor shall provide the piping leading to these intakes necessary *for him to comply* with the preceding specifications. *The pipe system shall be of standard wrought iron pipe, with smooth interior, and have its ends*

squared and reamed to remove all fins and burrs. All fittings shall be of the recessed drainage type, with long turns, wherever possible. All pipe must be fitted with red lead and oil and properly screwed home. All intake valves shall be of an approved type, and the finish shall conform to the finish of the hardware in the room in which they are placed.

HOSE.

The contractor shall furnish.....lengths of the best quality of reinforced vacuum hose of a diameter suitable for use with his particular system. Each length shall have proper couplings supplied so that it may be connected to any intake or any other piece of hose or to any tool.

TOOLS.

The contractor shall furnish.....sets of tools for the rapid removal of dust, dirt and grit from carpets, rugs, draperies, upholstery, wood, marble, decorations, walls, ceilings, books, cases, radiators, etc. Tools shall be as light as possible and the handles shall be seamless steel tubing with swivel joint attachments.

TESTING.

After the entire system has been installed, the contractor shall conduct a test in the presence of the architect or engineer to demonstrate the condition of the machine, and to determine whether the equipment thoroughly and satisfactorily removes all dry dirt and dust from all parts of the building, and to show that the tools are suitable for the several uses for which they were furnished, and that the specification and guarantee have been fully complied with.

GUARANTY.

We will construct the said apparatus, as specified, in a thorough and workmanlike manner, using suitable materials, and will furnish free of cost any part of said apparatus which may prove defective, either in material or workmanship, during one year from the completion of our work; natural wear and tear, accidents by fire or otherwise, excepted.

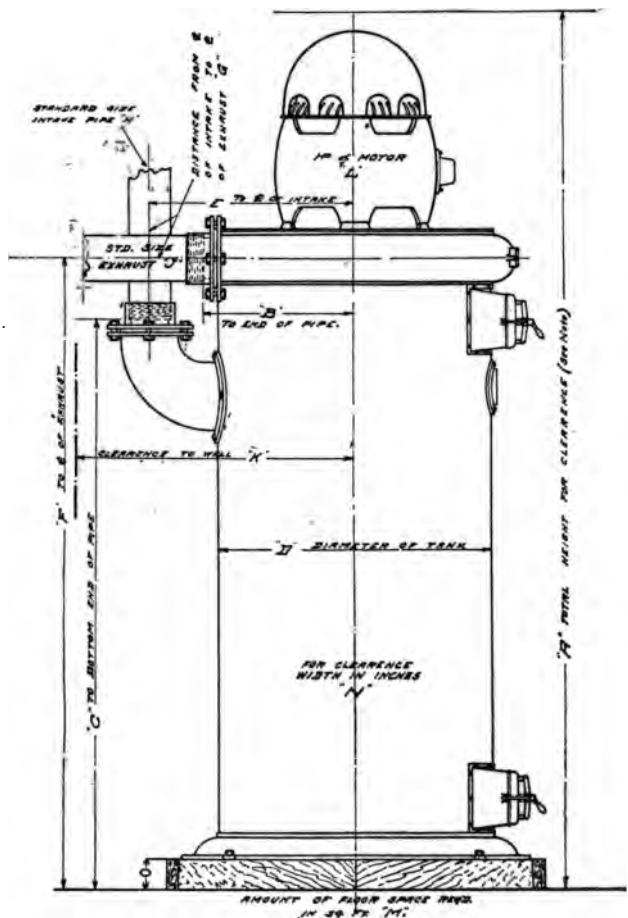
—II CODE II—

TO GENERAL DIMENSIONS OF TUBC MACHINES.

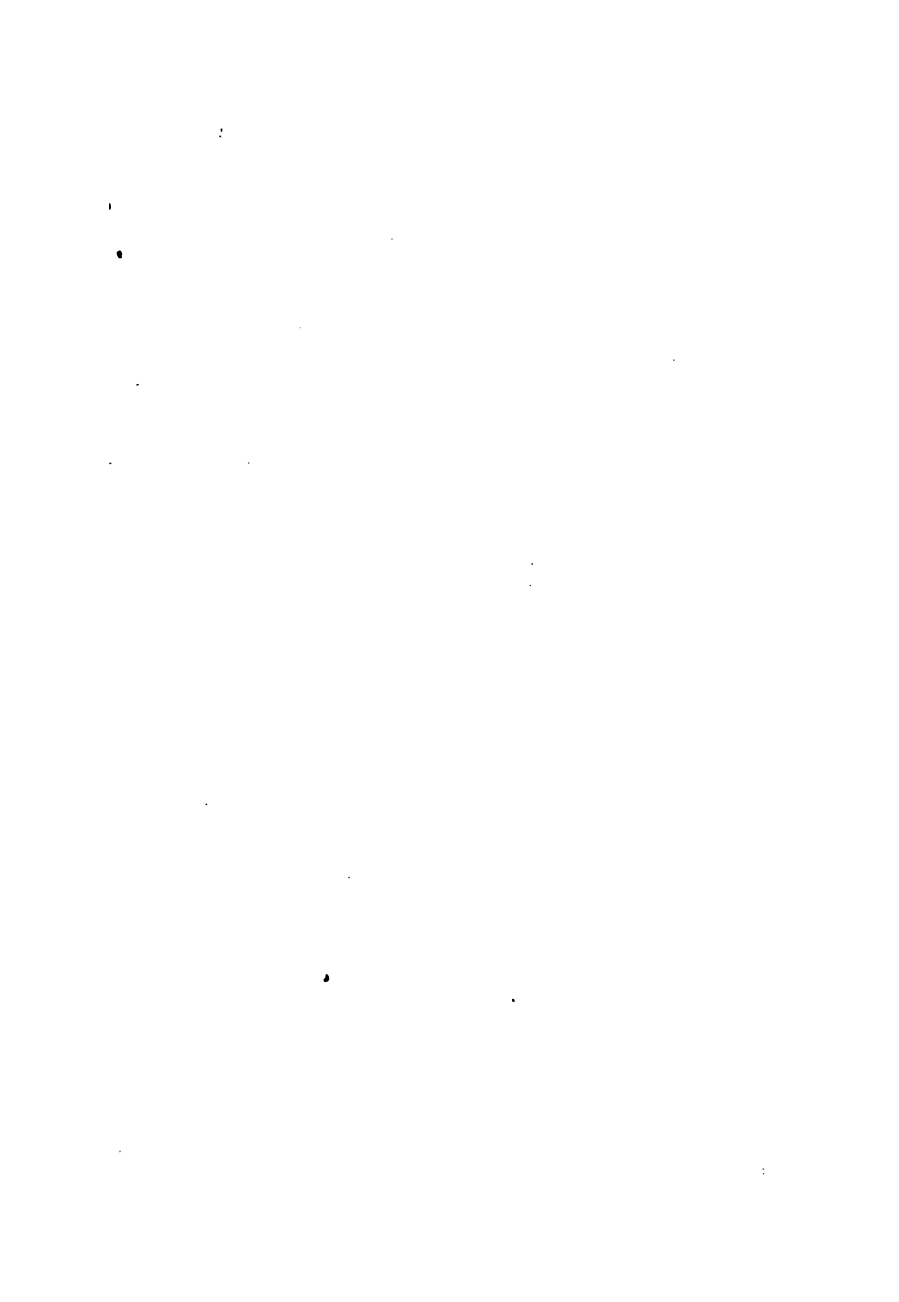
NUMBER OF MACHINE	NUMBER OF SPEEDS	SYMBOL														APP. HEIGHT OF MACHINE CANTED	
		A	B	C	D	E	F	G	H	J	K	L	M	N	O		
170	1	AC-4-2 BC-5-2	10½	39½	18	15½	43	8½	2½	3	18	0.5	4½	24	3½	275°	375°
200	1	AC-5-6 BC-5-6	10½	41½	18	13½	45	8½	2½	3	18	0.8	4½	24	3½	290°	400°
240	1	AC-5-7 BC-5-10	11½	40	20	14½	45½	10½	3	3	23	1.5	5½	28	1½	400°	550°
300	1	AC-6-2 BC-6-6	13½	41½	24	17	49½	12½	5½	4	26	2.5	8	38	1½	775°	950°
400	2	AC-6-7 BC-7-2	13½	46½	24	17	55½	12½	5½	4	26	3.5	8	38	1½	850°	1050°
600	3	AC-7-6 BC-7-6	13½	51½	28	20	59½	13	4	5	29	5.0	9½	42	1½	950°	1200°
800	4	AC-7-8 BC-7-8	13½	52	28	20	60	13	4½	5	29	6.5	9½	42	1½	1000°	1250°
1000	5	AC-8-6 BC-8-2	13½	56	28	20	64	13	5	5	29	8.0	9½	42	1½	1050	1300°
1200	6	AC-8-8 BC-8-8	13½	60	28	20	68	13	5	5	29	10.0	9½	42	1½	1100°	1350°

NOTE: DIMENSION "A" ALLOWS FOR REMOVING MOTOR IN CASE OF REPAIRS.

Table of Outside Dimensions per illustration following page.



Note—See opposite page for Dimensions.



20. 2nd



re ad









